

Remarks

Reconsideration of this Application is respectfully requested.

Upon entry of the foregoing amendments, claims 1-9 are pending in the application, with claim 1 being the independent claim.

Based on the following remarks, Applicants respectfully request that the Examiner reconsider all outstanding objections and rejections and that they be withdrawn.

I. Rejections of claims 1-7 and 9 under 35 U.S.C. § 103(a)

Claims 1-7 and 9 were rejected under 35 U.S.C. §103(a) as allegedly being unpatentable over Hwang *et al.* (*J. Mater. Chem.* 11:1722-1725 (2001)). Specifically, the Examiner alleged that Hwang describes sonication of a CNT solution for 10 minutes. However, the Examiner acknowledged that Hwang does not provide for an extended sonication period of 2 to 10 hours. (Office Action, pg. 2, last ¶). The Examiner alleged that it would have been obvious for one of ordinary skill in the art to optimize the sonication period in order to achieve a homogeneous dispersion of CNTs. For evidence of this allegation, the Examiner alleged that Smalley *et al.* (*J. Nanosci. Nanotech* 3:81-86 (2003)) describes the relationship between sonication time and CNT dispersion for time periods up to 5 hours. Applicants respectfully traverse this rejection.

To establish a *prima facie* case of obviousness, the art cited by the Examiner must (1) teach all of the claim limitations; (2) provide a suggestion or motivation to those of ordinary skill in the art to make the claimed composition; and (3) reveal that one of ordinary skill would have a reasonable expectation of success in doing so. *See In re*

Vaech, 20 USPQ2d 1438, 1442 (Fed. Cir. 1991); *see also* M.P.E.P. § 706.02(j). The United States Supreme Court, in *KSR International vs. Teleflex, Inc.*, 550 U.S. ___, WL 1237837 (April 30, 2007), further clarified the requirements for obviousness analysis under 35 U.S.C. 103(a). The Court noted that the analysis supporting a rejection under 35 U.S.C. 103(a) should be made **explicit**, and that it was "important to identify a reason that would have prompted a person of ordinary skill in the relevant field to combine the [prior art] elements" in the manner claimed. The Court specifically stated:

Often, it will be necessary for a court to look to interrelated teachings of multiple patents; the effects of demands known to the design community or present in the marketplace; and the background knowledge possessed by a person having ordinary skill in the art, all in order to determine whether there was ***an apparent reason*** to combine the known elements in the fashion claimed by the patent at issue. To facilitate review, ***this analysis should be made explicit***. (*KSR*, slip opinion, page 14, *citing In Re Kahn*, 441 F. 3d 977,988 (CA, Fed. 2006) ([R]ejections on obviousness grounds ***cannot be sustained by mere conclusory*** statements, instead, there must be some articulated reasoning with some rational underpinning to support a legal conclusion of obviousness").

"There is no suggestion to combine . . . if a reference teaches away from its combination with another source." *Tec Air, Inc. v. Denso Manufacturing Michigan Inc.*, 192 F.3d 1353, 1360 (Fed. Cir. 1999); *see also KSR*, U.S. LEXIS 4745 at *34 (reaffirming "the corollary principle that when the prior art teaches away from combining certain known elements, discovery of a successful means of combining them is more likely to be nonobvious") (citing *United States v. Adams*, 383 U.S. 39, 51-52 (1966)). "A reference may be said to teach away when a person of ordinary skill, upon reading the reference, would be discouraged from following the path set out in the reference, *or would be led in a direction divergent from the path that was taken by the applicant . . .*" *In re Gurley*, 27 F.3d 551, 553 (Fed. Cir. 1994) (emphasis added).

Hwang and Smalley do not teach or suggest carbon nanotubes homogeneously dispersed in a ceramic matrix

Claim 1 requires that the carbon nanotubes are *homogeneously dispersed* in the ceramic matrix to form nanocomposite powders. Hwang does not teach homogeneous dispersion of carbon nanotubes in the ceramic matrix to form nanocomposite powders. Rather Hwang discloses coating of individual nanotubes with SiO₂ to form *microrods*. For example, Hwang discloses that carbon nanotubes are added to a surfactant, sonicated for 10 minutes with sodium silicate and sodium aluminate, and then slowly titrated with H₂SO₄ to initiate polymerization (pg 1722, 1st col., last ¶ - 2nd col., 1st ¶). Using this process, Hwang formed "long rod shaped particles of micrometer lengths." (pg 1722, 2nd col., 1st ¶). Evidence of these relatively large SiO₂-CNT microrod structures is found in the scanning electron microscopy image of Fig. 1. The "micrometer sized SiO₂-CNT rods were then mixed with SiO₂ powder and pressed into a disc." (pg 1722, 2nd col., 1st ¶). The "silicate-surfactant-CNT co-micelles have a tendency to align in parallel and so form large diameter glass rods." (pg. 1723, 2nd col. last ¶ - 1724, 1st col., 1st ¶). The carbon nanotubes in Hwang are not homogeneously dispersed into a matrix, but rather are aligned and structured into rods, the rods then being pressed into a disc. Smalley does not even teach a ceramic matrix, let alone carbon nanotubes homogeneously dispersed in a ceramic matrix. Thus, neither Hwang nor Smalley disclose or provide a reason to make carbon nanotubes homogeneously dispersed a ceramic matrix. Applicants respectfully request that the rejection be withdrawn.

Hwang and Smalley do not disclose or provide a reason for sonication for 2 to 10 hours

Claim 1 requires the sonication of carbon nanotubes in the salt dispersion medium of (c) for 2 to 10 hours. The Examiner has acknowledged that Hwang does not describe sonication of the dispersion for 2 to 10 hours. However, the Examiner alleges that Smalley cures this deficiency.

A prior art reference must be considered in its entirety, i.e., as a whole, including portions that would lead away from the claimed invention. *W.L. Gore & Associates, Inc. v. Garlock, Inc.*, 721 F.2d 1540, 220 USPQ 303 (Fed. Cir. 1983), *cert. denied*, 469 U.S. 851 (1984). The totality of the prior art must be considered, and proceeding contrary to accepted wisdom in the art is evidence of nonobviousness. *In re Hedges*, 783 F.2d 1038, 228 USPQ 685 (Fed. Cir. 1986).

The Examiner has alleged that Smalley "elucidated the relationship between sonication time and CNT dispersion in aqueous solutions for timeperiods up to approximately 5 hours." (Office action, page 3, 1st ¶). The Examiner has also acknowledged that "fluorescence intensity 'saturates' between [surfactant] aliquot additions." (Advisory Action, page 2, 2nd ¶). However, the Examiner did not acknowledge that the "saturation" *occurs in about 20 minutes to 1 hour*. (Smalley pg. 82, 2nd col., 1st ¶). The Smalley reference *must be taken as a whole*, and not simply point out one element (the X-axis of Fig. 2) without considering the context of the article. A review of the *entire* disclosure of Smalley would not have provided a motivation for sonicating for 2 to 10 hours. In fact, a review of the entire Smalley reference would have taught away from sonicating for extended periods of time.

Examples of these teachings away are highlighted throughout the Smalley article. Some examples of these teachings away from extended sonication times include the following.

First, Smalley notes that "[a]fter each addition of surfactant, the fluorescence intensity rises and stabilizes to a steady state value over a period of about 20 min to 1 h, depending on the amount of added surfactant." (pg. 82, col. 2, emphasis added). The rise in intensity correlates with increased debundling of the carbon nanotubes, indicating an increase in dispersion. Thus, Smalley teaches that the dispersion "stabilizes to a steady state value" when sonicated for a period of from *20 minutes to one hour*. Since Smalley teaches the debundling reaches a steady state (i.e., no increase in dispersion) at 20 minutes to one hour, one of skill in the art would not have been motivated to sonicate the dispersion of the present invention for over 1 hour, let alone from 2 to 10 hours, i.e., there would have been no reason for one of skill in the art to sonicate beyond one hour, based on Smalley.

Second, Smalley notes that dispersion (as exemplified by a change in emission or fluorescence) does not occur in the absence of surfactant, stating "[n]o emission is evident at the start of the experiment, where sonication proceeds in the absence of surfactant" (pg. 82, bottom of col. 1-top of col. 2, emphasis added) and "[f]luorescence becomes observable during sonication *only with the addition of surfactant*, indicating that the adsorbed phase plays a critical role in the debundling process" (pg 83, col. 2, 3rd paragraph, emphasis added). In view of Smalley, one of skill in the art would have been motivated to add a surfactant, not sonicate for an extended period of time, to increase dispersion. This would also have been consistent with the teaching in Hwang. Thus,

Smalley does not provide motivation or a reason to sonicate the dispersion of the present invention for 2 to 10 hours.

Third, the experiments performed by Smalley allow Smalley to propose a model for the dispersion process. This model is expressed as mathematical formulae in Equations (1)-(5). None of the variables in Equations (1)-(5) are a function of sonication time. In fact, the rate of change of the concentration of individual nanotubes as a function of time ($\partial C_I / \partial t$) can be found in Equation (2) on page 84, second column:

$$\frac{\partial C_I}{\partial t} = k_z C_b C_{SDS} - \frac{k_z}{K_{eq}} C_I$$

wherein k_z is the bundle unzipping rate, C_b is the concentration of bundled nanotubes, C_{SDS} is the concentration of SDS monomer, K_{eq} is the equilibrium constant between individual nanotubes and bundles, and C_I is the concentration of individual nanotubes. Thus, Smalley's own model teaches that the rate of forming individual nanotubes from bundled nanotubes is a function of surfactant concentration, not a function of sonication time. There is no variable for the function of sonication time. Thus, one of skill in the art would *not* have been motivated to sonicate the nanotubes as described by Hwang for 2 to 10 hours. In fact, Smalley would have taught away from extended sonications by providing a reason to only to alter the surfactant concentration. Thus, Smalley does not provide motivation to sonicate the dispersion of the present invention for 2 to 10 hours.

Fourth, the Examiner alleged that Fig. 2 represented the "relationship between sonication time and CNT dispersion in aqueous solutions for time periods up to approximately 5 hours." (Office action, pg. 3, 1st ¶). However, Fig. 2 actually highlights the effects of addition of *surfactants* to the dispersion, since surfactant

concentration is increased over time. The Examiner's attention is directed to the Roman numerals located in Fig. 2, representing the addition of additional surfactants. Thus, Fig. 2 describes the increased dispersion of CNTs as a function of *surfactant concentration*, not as a function of *sonication time*. In fact, Fig. 2 demonstrates that for a given surfactant concentration, the rate of dispersion slows to almost equilibrium. This slowed rate of dispersion over time to equilibrium, followed by increased rate of dispersion upon addition of more surfactant, results in the plotted data appearing to be "scalloped." Thus, Fig. 2 would have taught one of skill in the art to add surfactant to increase dispersion, and would have taught away from sonicating for 2 to 10 hours. Therefore, Smalley does not provide motivation to sonicate the dispersion of the present invention for 2 to 10 hours.

In view of the fact that the Examiner has acknowledged that Hwang does not provide for an extended sonication period of 2 to 10 hours, and that the secondary reference of Smalley *considered in its entirety* does not provide a reason to sonicate for 2 to 10 hours, Applicants submit that the Examiner has failed to establish a *prima facie* case of obviousness, since the Examiner does not provide an *explicit analysis or reasoning* as to why the references would be combined by a person of ordinary skill in the art. *See, KSR v. Teleflex, supra.*

Furthermore, due to the teachings away of Smalley, one of skill in the art would not have a reasonable expectation of success. Upon consideration of the above, Applicants respectfully request that the rejections under 35 U.S.C. § 103(a) with respect to the Hwang in further view of Smalley be withdrawn.

II. Rejections of claim 8 under 35 U.S.C. § 103(a)

Claim 8 was rejected under 35 U.S.C. §103(a) as allegedly being unpatentable over Hwang *et al.* in further view of Chang (U.S. Pat. No. 6,420,293). Specifically, the Examiner alleges that Hwang teaches that the SiO₂-CNT powder is to be calcinated in an N₂ atmosphere at 1050°C, which falls between the claimed temperature range of 400-1700°C. The Examiner acknowledges that Hwang fails to explicitly set forth that the calcination of the ceramic matrix should be performed under a high vacuum. However, the Examiner alleges that Chang teaches that the heating of carbon nanotube materials at elevated temperatures in an oxidizing environment typically results in chemical changes in the surface of the particles, and that both N₂ atmospheres and high vacuum environments are commonly utilized as non-oxidizing environments. Thus, the Examiner alleges that the high vacuum environment would be an obvious alternative to the nitrogen atmosphere in Hwang. Applicants respectfully traverse this rejection.

To establish a *prima facie* case of obviousness, the cited document(s) must teach or suggest each and every element of the claimed invention. Claim 8 is dependent on claim 1. Claim 1 features (i) carbon nanotubes homogenously dispersed in a ceramic matrix , and (ii) that the carbon nanotubes in the salt dispersion medium of (c) be sonicated for 2 to 10 hours. Hwang does not teach or suggest the features of either (i) or (ii). Likewise, Chang does not teach or suggest the features of (i) or (ii). Thus, neither Hwang nor Chang teach or suggest each and every element of claim 1, either individually or collectively. Since claim 8 is dependent on claim 1, then each and every element of claim 8 is also not taught or suggested. For at least the above argument, and in further view of the arguments for claim 1-7 and 9 filed herein, the rejection of claim 8

under 35 U.S.C. §103 as allegedly being obvious by Hwang *et al.* in view of Chang should be withdrawn.

Conclusion

All of the stated grounds of objection and rejection have been properly traversed, accommodated, or rendered moot. Applicants therefore respectfully request that the Examiner reconsider all presently outstanding objections and rejections and that they be withdrawn. Applicants believe that a full and complete reply has been made to the outstanding Office Action and, as such, the present application is in condition for allowance. If the Examiner believes, for any reason, that personal communication will expedite prosecution of this application, the Examiner is invited to telephone the undersigned at the number provided.

Prompt and favorable consideration of this Amendment and Reply is respectfully requested.

Respectfully submitted,

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